BEST AVAILABLE COPY

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04J 1/00

A1

(11) International Publication Number: WO 96/35271

(43) International Publication Date: 7 November 1996 (07.11.96)

(21) International Application Number: PCT/US96/06000

(22) International Filing Date: 17 April 1996 (17.04.96)

(30) Priority Data:
08/433,878 2 May 1995 (02.05.95) US

(71) Applicant: MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors: PERREAULT, John, A.; 219 Ash Street, Hopkinton, MA 01748 (US). JOSHI, Abhay; 480 Normandy Drive, Norwood, MA 02062 (US). CHEN, Albert; 1595 Laburnum Road, Hoffman Estates, IL 60195 (US). LABOWICZ, Eva; 531 Newberry Drive, Elk Grove, IL 60007 (US).

(74) Agents: STOCKLEY, Darleen, J. et al.; Motorola Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

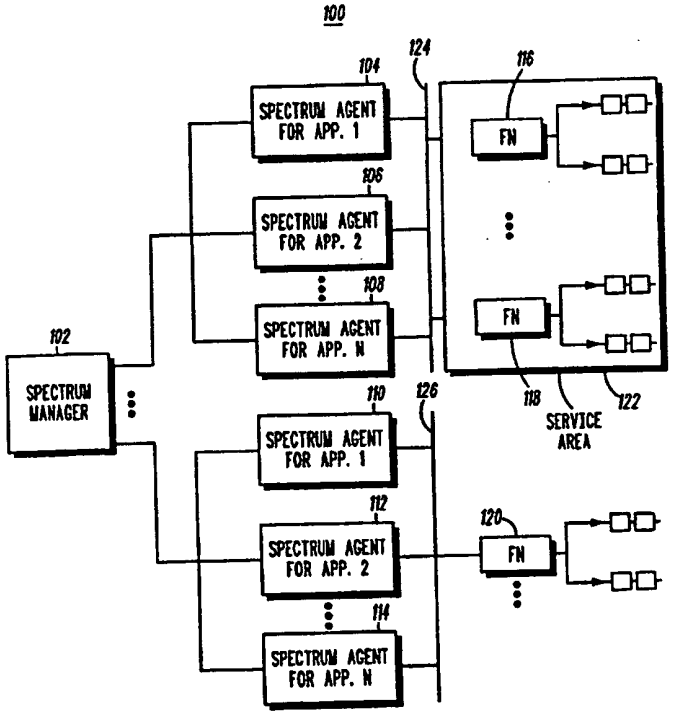
(81) Designated States: AU, CA, CN, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM

(57) Abstract

Frequency spectrum management provides for dynamic spectrum usage adjustment among applications on a shared medium. Dynamic resource management methods are applied to the problem of managing spectrum and matching application specific requirements to real-time spectrum characteristics so that more optimal use of the available spectrum may be made. At least a first spectrum agent is assigned to each of the plurality of different applications (104, 106, 108, 110, 112 and 114), for managing channels allocated to the application, and a spectrum manager (102) allocates frequency channel(s) to the plurality of different applications (104, 106, 108, 110, 112 and 114) based on the following at least one of parameters of a frequency channel required to implement the application and predetermined requirements based on time of day demand changes for the application.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	**GB**	United Kingdom	**MW**	Malawi
AT	Austria	**GE**	Georgia	**MX**	Mexico
AU	Australia	**GN**	Guinea	**NE**	Niger
BB	Barbados	**GR**	Greece	**NL**	Netherlands
BE	Belgium	**HU**	Hungary	**NO**	Norway
BF	Burkina Faso	**IE**	Ireland	**NZ**	New Zealand
BG	Bulgaria	**IT**	Italy	**PL**	Poland
BJ	Benin	**JP**	Japan	**PT**	Portugal
BR	Brazil	**KE**	Kenya	**RO**	Romania
BY	Belarus	**KG**	Kyrgystan	**RU**	Russian Federation
CA	Canada	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SG**	Singapore
CH	Switzerland	**KZ**	Kazakhstan	**SI**	Slovenia
CI	Côte d'Ivoire	**LI**	Liechtenstein	**SK**	Slovakia
CM	Cameroon	**LK**	Sri Lanka	**SN**	Senegal
CN	China	**LR**	Liberia	**SZ**	Swaziland
CS	Czechoslovakia	**LT**	Lithuania	**TD**	Chad
CZ	Czech Republic	**LU**	Luxembourg	**TG**	Togo
DE	Germany	**LV**	Latvia	**TJ**	Tajikistan
DK	Denmark	**MC**	Monaco	**TT**	Trinidad and Tobago
EE	Estonia	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**UG**	Uganda
FI	Finland	**ML**	Mali	**US**	United States of America
FR	France	**MN**	Mongolia	**UZ**	Uzbekistan
GA	Gabon	**MR**	Mauritania	**VN**	Viet Nam

METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM

Co-Pending Applications

The present application may be related to co-pending applications: CX095004, METHOD AND APPARATUS FOR A HYBRID CONTENTION AND POLLING PROTOCOL by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder; CX095005, METHOD AND SYSTEM FOR PROVIDING ACCESS BY SECONDARY STATIONS TO A SHARED TRANSMISSION MEDIUM, by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder; CX095007, METHOD AND APPARATUS FOR MULTILING POLLING, by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder; CX095009, METHOD AND APPARATUS FOR A HYBRID LIMITED CONTENTION AND POLLING PROTOCOL, by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder; CX095011, SYSTEM AND METHOD FOR HYBRID CONTENTION/POLLING PROTOCOL COLLISION RESOLUTION USING A COLLISION RESOLUTION USING A DEPTH FIRST SEARCH TECHNIQUE, by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder; and CX095012, METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM, by Abhay Joshi, Mete Kabatepe, Lawrence W. Lloyd, John A. Perreault, And Stephen Schroeder.

Field of the Invention

The present invention relates to spectrum management in communication systems, and more

particularly, to spectrum management among multiple applications in communication systems.

Background

Mechanisms for sharing frequency spectrum among various applications statically typically allocate a portion of the spectrum to each of the applications within a service area. This allocation cannot be undone without disabling the applications. Also, current mechanisms do not take into consideration the suitability of the allocated spectrum for serving a specific application.

Hence, current spectrum management approaches suffer from the following drawbacks:

Current algorithms do not allow dynamic sharing of spectrum between applications supported in a service area.

The algorithms used do not take into account the specific communications requirements associated with each specific application that is using spectrum. For example, the quality of a band of spectrum may be suitable for one application but not for another at any given instant of time. Hence, spectrum statically allocated to a specific application may not be the most suitable spectrum for that application.

Once allocated to an application, spectrum cannot be deallocated without disabling the application. If the application designates a portion of, or the entire spectrum allocated to it as unusable, that spectrum is wasted even though that spectrum may have been useful for some other application within the service area.

The characteristics of spectrum change over time. Hence, if some specific spectrum is suitable for the use

of an application currently, it may not be suitable over all the time period that it is allocated to the application, resulting in poor service to the application's users over time. The present static spectrum allocation mechanisms do not characterize spectrum characteristics by Time of Day (TOD) and intelligently determine spectrum usability for different TODs.

An individual application may have the ability to shrink its spectrum usage and free up spectrum for the use of other higher priority applications within the service area by reducing or denying service to some of its users. Current spectrum management mechanisms do not allow this dynamic spectrum usage adjustment.

Thus, there is a need for a method and system of frequency spectrum management that provides for dynamic spectrum usage adjustment among applications on a shared medium.

Brief Descriptions of the Drawings

FIG. 1 is a block diagram of a system suitable for implementing the method of the present invention.

FIG. 2 is a flow chart of one embodiment of steps in accordance with the method of the present invention.

Detailed Description of a Preferred Embodiment

The present invention applies dynamic resource management methods to the problem of managing spectrum and matching application specific requirements to real-time spectrum characteristics so

that more optimal use of the available spectrum may be made. Though wireless systems utilize dynamic carrier sharing that provides for sharing of available carriers among cells, applications are not matched to real-time spectrum characteristics.

Dynamic resource management is accomplished in the present invention by: 1) monitoring of channels for quality level (a measured quality level); 2) determining related characteristics, e.g., channel speed, propagation delay (maximum and minimum), etc., automatically; 3) maintaining a history of channel quality to be used for detecting trends; 4) applying characteristics to channels (e.g., channel speed, propagation delay, quality level, stability, etc.); 5) prioritizing channels for specific applications (e.g., voice, data, etc.) based on the characteristics of the channel; 6) allocating specific channels that are suitable for the use of specific applications to those applications; and 7) monitoring usage characteristics and channel characteristics of channels allocated to each application and allocating or deallocating channels to applications to maintain service to the application's users.

Typically, radio frequency (RF) spectrum is allocated for multiple applications, e.g., data, voice, and video, in a broadband cable network. The RF spectrum is generally sharable within a serving area. Dynamic allocation of the RF spectrum provides efficiency and convenience to the users. Referring to FIG. 1, numeral 100, the spectrum manager is responsible for the overall management of the spectrum allocated for its use in one or more service areas. Within a service area, a spectrum manager (102) dynamically allocates and

deallocates spectrum for the use of individual applications like voice, data, video etc.

Allocation of spectrum by the spectrum manager (102) is done by allocating frequency channels suitable for the use of each of the applications within the service area. The specific frequency channels allocated depend on the nature of the application and its requirements. Spectrum agents (104, 106, ..., 108; 110, 112, ...114) manage channels allocated to an application (APP. 1, 2, ...N, N a positive integer) and assign and deassign individual users of the application to the frequency channels. The spectrum agents (104, 106, ..., 108; 110, 112, ...114) are responsible for serving all the application's users within a service area (122, ...). Within a service area more than one spectrum agent may serve the same application, but for distinct users.

The service area (122, ...) may contain one or more fiber nodes (FN; 116, ..., 118; 120, ...) with the restriction that a frequency channel assigned by the spectrum agent is shared by all the fiber nodes within the service area (FN 116, ..., 118), i.e., where a frequency channel (124) is designated as assigned on one fiber node (e.g., 116), it is also considered to be assigned on the other fiber nodes (..., 118) within that service area. The fiber node may serve multiple individual users that may use different applications.

The spectrum manager manages a channel pool (124, 126, ...) allocated to one or more service areas. Each service area (122, ...) has a frequency channel pool (124, ...) allocated, which is shared by various applications (telephony, data, video) under the control of the spectrum manager (102). Each application (APP.

1, ...N) has its own spectrum agent (104, 106, ..., 108; 110, 112, ...114), which manages channels allocated to the application. Within a service area more than one spectrum agent may serve the same application, but for distinct users. Typically, the spectrum manager is a centralized controller, e.g., a microprocessor, and the spectrum agents are independent slaves managed by the centralized controller. Where selected, the spectrum agents may be collocated with the spectrum manager. The spectrum manager (102) makes decisions on channel allocation to the various applications based on at least the following two considerations:

1) Frequency channels are allocated to applications based on their suitability of use for that specific application. The parameters of a frequency channel to be considered for determining its suitability are its quality, bandwidth and intermediate frequency. This applies for both upstream and downstream channels. Channel quality is a measure of the current error rate and the stability of the channel. Stability is a measure of how frequently (or infrequently) and for what time duration, the channel experiences errors during its operation. Channel bandwidth is the spectral width of the channel. Each application operating within the service area has specific requirements of channel quality and channel bandwidth. For example a data application may not tolerate channel errors as well as a voice application. The quality, bandwidth and intermediate frequency required by an application will depend on the modulation used on the transmission medium by that application.

2) Frequency channels may be allocated to applications for their requirements based on their time of day demand changes. The time of day (TOD) demand could be based on a configured requirement for each of

the applications at various TODs or based on historical information on each of the application's TOD demand. The historical information will be built over time by monitoring the demand of each of the applications. The spectrum manager will use this information to adjust the channel allocation between the applications based on their TOD requirements. Frequency channels are also characterized by their TOD behavior. For example some frequency channels may historically present a bad quality (high error rate) at certain TODs. This channel could be defined to be usable by some applications and not usable by some other applications at various TOD. The spectrum manager will use this information to assign certain specific channels to specific applications whose quality requirements will be satisfied by those channels at that TOD.

FIG. 2, numeral 200, is a flow chart of one embodiment of steps in accordance with the method of the present invention. The method provides efficient management of a channel pool that is allocated among a plurality of different applications and has a predetermined number of frequency channels for a plurality of users in a communication system, wherein spectrum frequency of the channel pool is dynamically spread among the plurality of different applications to optimize provision of application requirements for applications in use. The method includes the steps of: A) assigning at least a first spectrum agent of the plurality of spectrum agents to each of the plurality of different applications, for managing channels allocated to the application; and B) allocating, by the spectrum manager, frequency channel(s) to the plurality of different applications based on the following at least one of: B1) parameters of a frequency channel required

to implement the application; and B2) predetermined requirements based on time of day demand changes for the application, wherein the at least first spectrum agent monitors all frequency channels currently allocated to the at least first spectrum agent and maintains current information for quality and usage metrics for each of the frequency channels allocated for the use of the application assigned to the at least first spectrum agent.

Where selected, coaxial cable may be utilized to couple at least some of the plurality of users to the communication system. Also, where selected, fiber optic cable may be utilized to couple at least some of the plurality of users to the communication system.

Each spectrum agent monitors all the frequency channels currently allocated to it and maintains current information of the quality and usage metrics of each of the frequency channels allocated for the use of its application. Based on this information, each spectrum agent classifies the channels assigned to its application as assigned, available and out of service and conveys this information to the spectrum manager (206). Typically, "assigned" means that the requirements of the application assigned to the channel are met and the channel is currently in use. "Available" means that the requirements of the application assigned to the channel are met, but the channel is not currently in use. "Out of service" means that the requirements of the application are unmet.

Hence the spectrum manager has current information about the quality of the channels allocated to each of the applications under its control. This

allows the spectrum manager to request the applications to reallocate out of service channels (208) that may be suitable for use by applications having more lenient quality requirements.

Similarly, the frequency spectrum manager may also switch (210) a frequency channel from the out of service list of one application with an available channel from another application having more lenient quality requirements. Thus, based on current information of the frequency channel usage of each application, the spectrum manager may reassign allocated channels.

Based on the criteria for allocating channels to applications, the spectrum manager may request any spectrum agent to return a specific channel (212) it has been allocated. Such a channel may be in the spectrum agent's assigned, available or out of service channel list. For example, where needed, the spectrum manager may use this capability to merge contiguous frequency channels to create a channel where more spectral bandwidth is required than is available in a single channel.

In addition, the spectrum manager may request any of the spectrum agents to return one or a number of any allocated channels (214). Where the spectrum manager does not specify which specific channel is to be returned, but only specifies the number and type of channels to be returned by the spectrum agent, the spectrum agent may respond by returning the requested number of channels of the specified type (214) so that the channels may be reallocated to other applications. A type of channel means that a channel's parameters, i.e., quality, bandwidth, and intermediate frequency,

meet a minimal set of requirements that is determined by the spectrum manager based on the application for which it is requesting the channel.

Further, the spectrum manager may request a spectrum agent to rate-adjust a frequency channel (216) and return a portion of the channel. For example, some modulation techniques allow the usage of varying spectrum, and hence the spectrum agents for applications using such a modulation technique may return a portion of a channel.

In some instances, some applications may use all the usable channels from the channels allocated to them by the spectrum manager. If required, these applications may shrink their channel usage by concentrating their users on fewer frequency channels than would be normally used if the network used by said applications is not heavily utilized. The spectrum manager can request such applications to assign users to fewer channels (218) and return some allocated channels from the assigned list of channels to serve other applications which may have a shortage of channels. Subsequently, if the channels become available again, the spectrum manager will return them to the original owner and allow the application to distribute users on all available channels. Such a mechanism provides maximum flexibility of channel usage to the application and the spectrum manager while providing the most efficient service to the users.

Where desired, priorities may be given (220) to various applications and also for individual users (222) within each application. This priority information may be used by the spectrum agent to grant or deny a request

made by the spectrum manager for a frequency channel. For example, if the spectrum manager requests any single channel from a spectrum agent with priority p (p a selected priority level value), the spectrum agent will grant that request if: 1) channels are listed in its available list or out of service list or 2) all the frequency channels allocated to the spectrum agent are assigned, but a channel may be made available by denying service to some users who have a service priority of less than p. Where selected, this mechanism may be utilized to guarantee access to a frequency channel for a critical application. Thus, predetermined priorities may be assigned to applications in accordance with a predetermined scheme. Further, predetermined priorities may be assigned to individual users of applications in accordance with the predetermined scheme.

The spectrum agent may also make channels available by decreasing service to its set of users (224), while still meeting an acceptable (minimum) level of service and return the available channels to the spectrum manager when a critical application needs channels. Thus, an application may selectably degrade service to its users instead of denying service. This is particularly suitable for applications which may operate end-to-end at variable rates (e.g., digital voice using coding algorithms PCM, ADPCM, VSELP).

The spectrum manager has information about the bandwidth and guard band requirements of the frequency channels required by each of the applications under its control. Hence the spectrum manager may combine channels, divide channels and manage the guard bands

between the channels when it combines or divides channels.

This invention provides a solution to the problem of optimizing the allocation of available spectrum of varying quality on a shared medium (e.g., coaxial cable, etc.) to multiple applications (e.g., data, telephony, video, etc.) with multiple users. Spectrum suitable for the use of an application is allocated for the application's use so that the application user's requirements may be maintained.

Time of day changes in the ability of specific spectrum to serve an application's requirements are monitored and, when changes in a channel cause the channel characteristics to fail to meet the application's requirements, the spectrum manager utilizes the above techniques to provide a channel that satisfies the application user's communication requirements.

Another advantage is that spectrum designated unusable by one application is not wasted if it can be used by another application which needs spectrum.

Spectrum usage within an application may be changed by rate-adjustment, by denying service to lower priority users to provide spectrum for higher priority applications, or by providing degraded but acceptable performance.

We claim:

1. A method of efficient management of a channel pool that is allocated among a plurality of different applications and has a predetermined number of frequency channels for a plurality of users in a communication system, wherein spectrum frequency of the channel pool is dynamically spread among the plurality of different applications to optimize provision of application requirements for applications in use, comprising the steps of:

A) assigning at least a first spectrum agent to each of the plurality of different applications, for managing channels allocated to the application;

B) allocating, by the spectrum manager, frequency channel(s) to the plurality of different applications based on the following at least one of:

B1) parameters of a frequency channel required to implement the application; and

B2) predetermined requirements based on time of day demand changes for the application,

wherein the at least first spectrum agent monitors all frequency channels currently allocated to the at least first spectrum agent and maintains current information for quality and usage metrics for each of the frequency channels allocated for the use of the application assigned to the at least first spectrum agent.

2. The method of claim 1 wherein at least one of 2A-2I:

2A) wherein coaxial cable is utilized to couple at least some of the plurality of users to the communication system;

2B) wherein fiber optic cable is utilized to couple at least some of the plurality of users to the communication system;

2C) wherein the parameters of the frequency channel required to implement the application include at least one of: quality, bandwidth and intermediate frequency;

2D) wherein time of day requirements are based on one of:

a requirement reconfigured for the application at predetermined times of day, and

historical information on the application's time of day requirements;

2E) including requesting, by the spectrum manager, at least one spectrum agent of the plurality of spectrum agents to return a particular channel allocated to the spectrum agent;

2F) including requesting, by the spectrum manager at least one of:

at least one channel; and

at least one specified type of channel;

2G) including rate-adjusting, by the at least first spectrum agent, a frequency channel and return a selected portion of the channel to the channel pool in response to a request by the spectrum manager;

2H) including assigning, by the at least first spectrum agent, in response to a request by the spectrum manager, more users of one application to a frequency channel and returning previously allocated channel(s) for the users for assignment to other applications; and

2I) including reallocating, by the at least first spectrum agent, channels that become available by decreasing service to its set of users, while still meeting a predetermined minimum level of service and returning the channels to the spectrum manager upon request.

3. The method of claim 1 wherein, in accordance with a predetermined scheme, the at least first spectrum agent classifies the channels assigned to its application as one of: assigned, available and out of service and conveying the

information to the spectrum manager, and where selected, at least one of 3A-3B:

3A) wherein the at least first spectrum agent further reassigns out of service channels to applications having more lenient quality requirements than the application for which the channel was classified out of service; and

3B) wherein the at least first spectrum manager further reassigns an out of service frequency channel of one application to an available channel from another application having more lenient quality requirements.

4. The method of claim 1 wherein predetermined priorities are assigned to applications in accordance with a predetermined scheme, and where selected, wherein predetermined priorities are further assigned to individual users of applications in accordance with the predetermined scheme.

5. A system for efficient management of a channel pool that is allocated among a plurality of different applications and has a predetermined number of frequency channels for a plurality of users in a communication system, wherein spectrum frequency of the channel pool is dynamically spread among the plurality of different applications to optimize provision of application requirements for applications in use, the system comprising:

a spectrum manager, for distributing, and dynamically allocating spectrum frequency among the plurality of users, in accordance with a predetermined scheme and

a plurality of spectrum agents, operably coupled to the spectrum manager and to the plurality of users, wherein the plurality of spectrum agents assign frequency channel(s) for different applications to the

plurality of users in a predetermined service area, in accordance with the predetermined scheme.

6. The system of claim 5 wherein the predetermined scheme includes:

6A) assigning at least a first spectrum agent of the plurality of spectrum agents to each of the plurality of different applications, for managing channels allocated to the application;

6B) allocating, by the spectrum manager, frequency channel(s) to the plurality of different applications based on the following at least one of:

6B1) parameters of a frequency channel required to implement the application; and

6B2) predetermined requirements based on time of day demand changes for the application,

wherein the at least first spectrum agent monitors all frequency channels currently allocated to the at least first spectrum agent and maintains current information for quality and usage metrics for each of the frequency channels allocated for the use of the application assigned to the at least first spectrum agent.

7. The system of claim 6 wherein at least one of 7A-7D:

7A) wherein coaxial cable is utilized to couple at least some of the plurality of users to the communication system;

7B) wherein fiber optic cable is utilized to couple at least some of the plurality of users to the communication system;

7C) wherein the parameters of the frequency channel required to implement the application include at least one of: quality, bandwidth and intermediate frequency; and

7D) wherein time of day requirements are based on one of:

a requirement reconfigured for the application at predetermined times of day, and

historical information on the application's time of day requirements.

8. The system of claim 6 wherein, in accordance with a predetermined scheme, the at least first spectrum agent classifies the channels assigned to its application as one of: assigned, available and out of service and conveys the information to the spectrum manager, and where selected, at least one of 8A-8B:

8A) wherein the at least first spectrum agent further reassigns out of service channels to applications having more lenient quality requirements than the application for which the channel was classified out of service; and

8B) wherein the at least first spectrum agent further reassigns an out of service frequency channel of one application to an available channel from another application having more lenient quality requirements.

9. The system of claim 6 wherein at least one of 9A-9E:

9A) including requesting, by the spectrum manager, at least one spectrum agent of the plurality of spectrum agents to return a particular channel allocated to the spectrum agent;

9B) including requesting, by the spectrum manager at least one of:

at least one channel; and

at least one specified type of channel;

9C) including rate-adjusting, by the at least first spectrum agent, a frequency channel and return a selected portion of the channel to the channel pool in response to a request by the spectrum manager;

9D) including assigning, by the at least first spectrum agent, in response to a request by the spectrum manager, more users of one application to a frequency channel and returning previously allocated channel(s) for the users for assignment to other applications; and

9E) including reallocating, by the at least first spectrum agent, channels that become available by decreasing service to its set of users, while still meeting a predetermined minimum level of service and returning the channels to the spectrum manager upon request.

10. The system of claim 6 wherein predetermined priorities are assigned to applications in accordance with a predetermined scheme, and where selected, wherein predetermined priorities are further assigned to individual users of applications in accordance with the predetermined scheme.

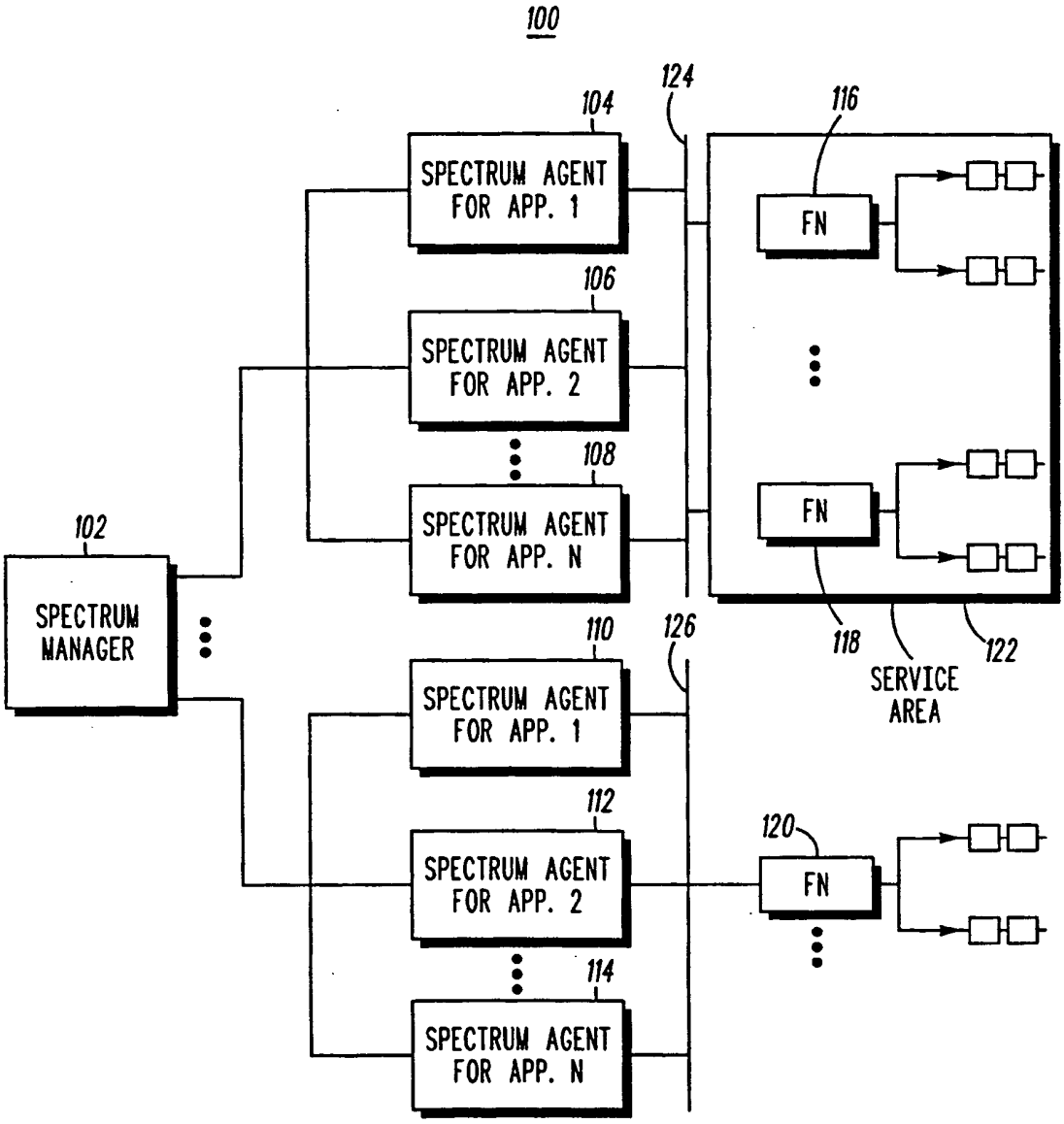
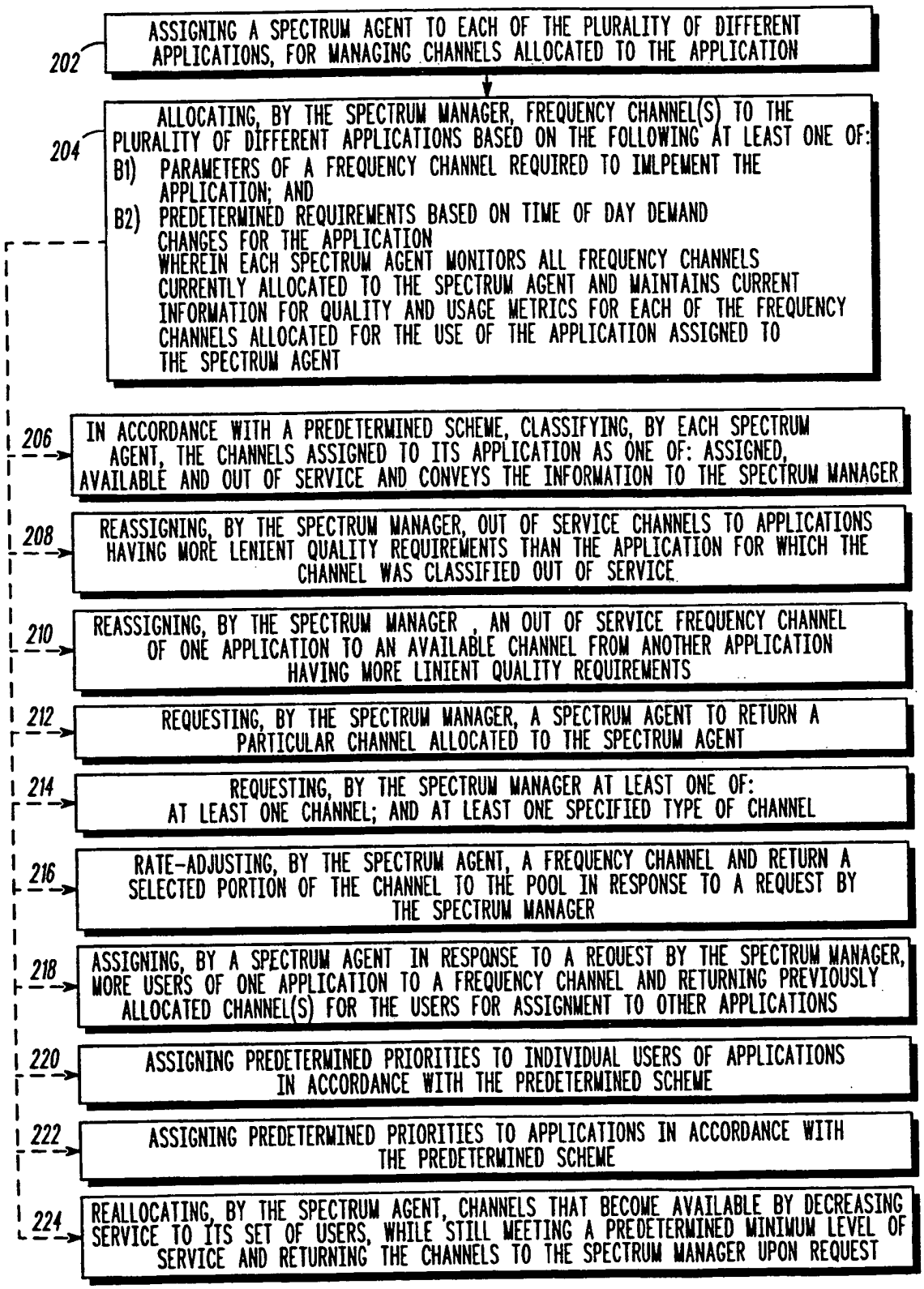

100
124
104
116
SPECTRUM AGENT FOR APP. 1
FN
106
SPECTRUM AGENT FOR APP. 2
108
SPECTRUM AGENT FOR APP. N
FN
102
SPECTRUM MANAGER
110
126
SPECTRUM AGENT FOR APP. 1
118
SERVICE AREA
122
112
120
SPECTRUM AGENT FOR APP. 2
FN
114
SPECTRUM AGENT FOR APP. N

FIG.1

FIG. 2


200
202
ASSIGNING A SPECTRUM AGENT TO EACH OF THE PLURALITY OF DIFFERENT APPLICATIONS, FOR MANAGING CHANNELS ALLOCATED TO THE APPLICATION
204
ALLOCATING, BY THE SPECTRUM MANAGER, FREQUENCY CHANNEL(S) TO THE PLURALITY OF DIFFERENT APPLICATIONS BASED ON THE FOLLOWING AT LEAST ONE OF:
B1) PARAMETERS OF A FREQUENCY CHANNEL REQUIRED TO IMLPEMENT THE APPLICATION; AND
B2) PREDETERMINED REQUIREMENTS BASED ON TIME OF DAY DEMAND CHANGES FOR THE APPLICATION
WHEREIN EACH SPECTRUM AGENT MONITORS ALL FREQUENCY CHANNELS CURRENTLY ALLOCATED TO THE SPECTRUM AGENT AND MAINTAINS CURRENT INFORMATION FOR QUALITY AND USAGE METRICS FOR EACH OF THE FREQUENCY CHANNELS ALLOCATED FOR THE USE OF THE APPLICATION ASSIGNED TO THE SPECTRUM AGENT
206
IN ACCORDANCE WITH A PREDETERMINED SCHEME, CLASSIFYING, BY EACH SPECTRUM AGENT, THE CHANNELS ASSIGNED TO ITS APPLICATION AS ONE OF: ASSIGNED, AVAILABLE AND OUT OF SERVICE AND CONVEYS THE INFORMATION TO THE SPECTRUM MANAGER
208
REASSIGNING, BY THE SPECTRUM MANAGER, OUT OF SERVICE CHANNELS TO APPLICATIONS HAVING MORE LENIENT QUALITY REQUIREMENTS THAN THE APPLICATION FOR WHICH THE CHANNEL WAS CLASSIFIED OUT OF SERVICE
210
REASSIGNING, BY THE SPECTRUM MANAGER , AN OUT OF SERVICE FREQUENCY CHANNEL OF ONE APPLICATION TO AN AVAILABLE CHANNEL FROM ANOTHER APPLICATION HAVING MORE LINIENT QUALITY REQUIREMENTS
212
REQUESTING, BY THE SPECTRUM MANAGER, A SPECTRUM AGENT TO RETURN A PARTICULAR CHANNEL ALLOCATED TO THE SPECTRUM AGENT
214
REQUESTING, BY THE SPECTRUM MANAGER AT LEAST ONE OF:
AT LEAST ONE CHANNEL; AND AT LEAST ONE SPECIFIED TYPE OF CHANNEL
216
RATE-ADJUSTING, BY THE SPECTRUM AGENT, A FREQUENCY CHANNEL AND RETURN A SELECTED PORTION OF THE CHANNEL TO THE POOL IN RESPONSE TO A REQUEST BY THE SPECTRUM MANAGER
218
ASSIGNING, BY A SPECTRUM AGENT IN RESPONSE TO A REQUEST BY THE SPECTRUM MANAGER, MORE USERS OF ONE APPLICATION TO A FREQUENCY CHANNEL AND RETURNING PREVIOUSLY ALLOCATED CHANNEL(S) FOR THE USERS FOR ASSIGNMENT TO OTHER APPLICATIONS
220
ASSIGNING PREDETERMINED PRIORITIES TO INDIVIDUAL USERS OF APPLICATIONS IN ACCORDANCE WITH THE PREDETERMINED SCHEME
222
ASSIGNING PREDETERMINED PRIORITIES TO APPLICATIONS IN ACCORDANCE WITH THE PREDETERMINED SCHEME
224
REALLOCATING, BY THE SPECTRUM AGENT, CHANNELS THAT BECOME AVAILABLE BY DECREASING SERVICE TO ITS SET OF USERS, WHILE STILL MEETING A PREDETERMINED MINIMUM LEVEL OF SERVICE AND RETURNING THE CHANNELS TO THE SPECTRUM MANAGER UPON REQUEST

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06000

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04J 1/00
US CL :370/69.1,50,18,20,21;375/200,201,202,203,204,205
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/69.1,50,18,20,94.1,60,118,95.1,95.3,21;375/200,201,202,203,204,205 ;455/34.1,54.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,528,656(MORAIS) 09 July 1985,col.2 ,lines 41-66 and figures 1-2.	5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
28 JUNE 1996	25 JUL 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DANG TON Telephone No. (703)305-4739

Form PCT/ISA/210 (second sheet)(July 1992)*

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.